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# **EVIDENCE FOR THE BENEFITS OF TELECARDIOLOGY APPLICATIONS: A SYSTEMATIC REVIEW**

**David Hailey, Arto Ohinmaa, Risto Roine**

**October 2004**



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## SUMMARY

- This report reviews the literature on assessment of telecardiology, considering applications in pediatric care, hospital or clinic use for adults, emergency care, and home care.
- Computerized literature searches from 1992 to September 2003 were performed using electronic databases. Articles were selected which described, in a scientifically valid manner, studies reporting clinical, economic or administrative outcomes of telecardiology. Both controlled studies and non-controlled studies with not less than 20 subjects were included.
- The quality of the selected studies was assessed using the approach that took account of both study performance and study design to give an indication of the reliability of their results for decision makers.
- Reliability of studies was rated as **high** (high degree of confidence in the findings; **good** (some uncertainty regarding the findings; **fair** (some limitations that should be considered in any implementation of the findings; **poor to fair** (substantial limitations, findings should be used cautiously); or **poor** (findings were of unacceptable uncertainty).
- Those studies that included cost or economic data were also judged against accepted criteria for economic analysis.
- From 527 publications identified in the literature search, 46 papers describing 44 studies met the selection criteria and were included in the review.
- The majority of the studies (39 of 44) concluded that telecardiology had advantages over the alternative. However, the quality of 23 of these (59%) was poor or poor to fair.
- All but one of the studies on pediatric applications related to teletransmission of echocardiography data. Reported benefits included savings in time and cost through avoiding unnecessary referrals. Three studies were of fair quality, with the remainder providing weaker evidence. Economic analyses in six studies were of low or very low quality. The other pediatric study, on monitoring of pacemaker performance, provided weak evidence of benefit.
- Six of ten studies on applications in adult care considered support for primary care physicians through transmission of ECG results and feedback from cardiologists. There were benefits through avoidance of unnecessary referrals and identification of patients who required urgent intervention. One study was judged to be fair, with the others having lower reliability. Two other studies indicated benefits from use of telecardiology in a prison service and in support of a cardiac catheterization



laboratory. Feasibility was demonstrated, but benefits were less clear, in studies on use of telemetry outside critical care units and on transmission of nuclear medicine results.

- With emergency care applications three studies considered transmission of ECG data from ambulance to hospital and indicated benefits through faster diagnosis and more rapid treatment of patients. One of these studies was of good quality with the others giving weaker evidence. A good quality study on use of dobutamine stress echocardiography demonstrated benefits through avoidance of unnecessary hospitalization. A fair quality study indicated benefits from use of a fax-based system to provide out of hours support to hospital house officers.
- Nine of 13 home care application studies assessed telemonitoring of patients with heart failure. Benefits were demonstrated through reduction in hospital admissions, decreased hospital stay, and lower hospital costs. Four studies were RCTs of high quality, two were judged to be fair and three were poor to fair. One of the high quality studies also rated as fair to good for its economic analysis. Two high quality studies showed that home-based rehabilitation was as effective as programs undertaken within institutions. One good quality and one poor quality study indicated useful gains in performance in the monitoring of arrhythmias.
- The review shows that few studies of telecardiology in the recent literature have reported clinical or economic outcomes.
- On the basis of information given in the papers that were reviewed, the quality of over half the 44 studies were judged to be of poor or poor to fair. For decision-making purposes, they should be regarded as providing no more than preliminary indications of benefits and costs, requiring follow up to verify their findings.
- While telecardiology has had a long history, most of the studies reported in the literature do not provide convincing evidence of benefit.
- Decision makers should note the need for follow-up of preliminary studies in order to obtain reliable outcomes data for telecardiology applications.





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## INTRODUCTION

Telemedicine has been defined by the US National Library of Medicine as “*Delivery of health services via remote telecommunications. This includes interactive consultative and diagnostic services.*” In previous publications, we have reviewed available literature on the assessment of telemedicine <sup>1-3</sup>. In those reviews we considered studies that had included comparison of a telemedicine application with a non-telemedicine alternative and which had reported administrative changes, patient outcomes or results of economic assessment. The intention was to provide overviews of the available reasonable quality evidence on the efficacy, effectiveness and economic impact of telemedicine applications, as guidance for decision makers in health care and those with interest in this technology. These reviews indicated that although useful clinical and economic outcomes data have been obtained for some telemedicine applications, good quality studies are still scarce and generalisability of most assessment findings may be limited.

The present report reviews the literature on assessment of a particular area of telemedicine–telecardiology. A review of telemedicine evaluation by McDonald et al. <sup>4</sup> has noted that telecardiology is one of the oldest and most common applications of teletransmission. Telephone transmission of the electrocardiogram (ECG) was undertaken by Einthoven as long ago as 1911 and auscultation by telephone dates back to 1924. Later developments have included telephone (POTS) transmission ECGs for ambulatory arrhythmia detection and diagnosis of myocardial ischaemia, rural teleconsultation and tele-echocardiography.

Despite this long history, assessment of telecardiology is required in order to address newer versions of technologies and changes to organisation of health services. As with other areas of telemedicine, there is a need to consider safety, effectiveness, economic impact and access issues so as to inform decisions on planning and implementation on future health care services, and on standards of care.

The approach taken follows that in our earlier reviews, except that some consideration is given to non-comparative studies as well as to controlled trials. Four areas of telecardiology application are covered:

- Hospital/ clinic use – pediatric;
- Hospital/ clinic use – adult;
- Emergency care; and
- Home care.

Clinical, economic and administrative outcomes reported in the available literature are considered and also the potential influence of the reviewed studies on policy decisions.





## METHODS

### Literature Search

Computerized literature searches were performed using electronic database entries from 1992 to September 2003. There were no language restrictions. The data bases and the search strategy used are given in Appendix A.

### Selection of publications

Initial screening of the identified articles was based on their abstracts. All abstracts were read independently by all the authors. Selection of relevant articles was based on the information obtained from the abstracts and was agreed upon in discussion between the authors. When an abstract did not give sufficiently precise information about the study or such information was not available at all, the article was obtained for further review.

Articles were selected which described, in a scientifically valid manner, studies reporting clinical, economic or administrative outcomes of telecardiology in the specified areas of application. We included controlled studies in which there was comparison of telecardiology with a non-telemedicine alternative and also non-controlled studies that reported appropriate outcomes and where the numbers of subjects were not less than 20. We excluded studies that considered only technical issues; those that did no more than establish technical feasibility of telecardiology, including accuracy studies; non-controlled studies with fewer than 20 subjects; and studies where the information provided was insufficient to establish scientific credibility. Articles that were duplicates of other published studies were also excluded.

Full-text articles obtained for closer inspection were evaluated independently by the authors, who then reached a consensus on whether or not an article should be included in the final review, using the criteria given above.

In describing each study consideration was given to the objectives, approach taken, setting and subjects, type of economic analysis, results and conclusions of the investigators. Note was taken of any significant limitations.

### Assessment of quality and reliability

Quality of the selected studies was assessed using the approach described in a previous review<sup>3</sup>, considering both study performance and study design. For *study performance*, five areas of interest were considered, as shown in Table 1. When reviewing a telecardiology study, each of these five areas was given a score of 0, 1 or 2, based on the following observations:



0 = Relevant information was missing or given in only minimal detail

1 = Reasonable detail was provided but there were some important limitations

2 = Information was satisfactory, there were no significant limitations

Each study therefore had a possible maximum score of 10 for performance.

**Table 1: Classification of study performance**

Areas of interest		Points considered
1	Patient selection	Methods of randomization/ selection. Equivalence of intervention and control groups. Drop outs prior to commencement of intervention
2	Description/ specification of the interventions	Adequate description for both intervention and control groups
3	Specification and analysis of study	Sample size; statistical methods used; clear specification of outcome measures
4	Patient disposal	Length of follow-up; drop outs; compliance failures
5	Outcomes reported	Fullness and clarity of reporting. Missing results; statistical summary. Whether conclusions were consistent with data.

An additional score was allocated to each study, according to the *study design* that had been used. Details are shown in Table 2. Large randomized controlled trials (RCTs), defined for the purposes of this review as those with at least 50 subjects in each arm, were given a score of five. Smaller RCTs had a score of three, prospective non-randomized studies two, retrospective comparative studies one and non-controlled series a value of zero.

**Table 2: Classification of study design**

Study design	Score
Large RCT	5
Small RCT	3
Prospective, non – randomized comparative	2
Retrospective comparative	1
Non – controlled series	0

Each author independently assigned scores to each study. If the authors disagreed on the study design classification or if individual scores for any performance item differed from each other by more than one, the discrepancies were discussed and resolved by consensus. For each study, the mean of the authors' individual scores was reported to the nearest 0.5.



The performance and design scores were then combined to give an overall score for each study to give an indication of the confidence that decision makers should place in study findings. The maximum value was 15 (corresponding to a large RCT with no significant limitations). On the basis of the combined scores, we assigned each study to one of five categories to give an indication of the reliability of the findings that they reported. Details are shown in Table 3. The definitions of the reliability categories were based on a consensus judgment.

**Table 3: Quality scores and implications for decision makers**

Overall quality score	Reliability	Implications for decision makers
11.5 -15	A	High quality; high degree of confidence in study findings
9.5 – 11.0	B	Good quality; some uncertainty regarding the study findings
7.5 – 9.0	C	Fair quality; some limitations that should be considered in any implementation of study findings
5.5 – 7.0	D	Poor to fair quality; substantial limitations in the study, findings should be used cautiously
≤ 5.0	E	Poor quality; study findings have unacceptable uncertainty

Those studies that included cost or economic data were also assessed separately to provide an indication of the quality of the economic analysis that had been undertaken. Studies were judged against the criteria for economic analysis given by Drummond et al.<sup>5</sup>:

- Was a well-defined question posed in answerable form?
- Was a comprehensive description of the competing alternatives given?
- Was the effectiveness of the programmes or services established?
- Were all the important and relevant costs and consequences for each alternative identified?
- Were costs and consequences measured accurately in appropriate physical units?
- Were costs and consequences valued credibly?
- Were costs and consequences adjusted for different timing?
- Was an incremental analysis of costs and consequences of alternatives performed?
- Was allowance made for uncertainty in the estimates of costs and consequences?
- Did the presentation and discussion of the study results include all issues of concern to users?





Two of the authors reviewed the publications that included economic information. For those where sufficient information was presented to justify classification as an economic study, a score of 1 was given for each criterion that was fulfilled in a satisfactory way, with no significant limitations. A summary score from 0 to 10 was given to each study, with any difference in scores from the reviewers being resolved by consensus. If the study fulfilled at least five criteria, it was considered to provide at least moderately good information on the economic indications of the telecardiology application. These scores were separate to the design/ performance scores described previously.



## RESULTS

### Retrieved Articles

From the 527 publications identified in the literature search, 79 were retrieved for closer inspection. From these, 45 papers describing 43 studies were judged to meet the selection criteria and were included in the review. A further publication was identified though from a separate project to give a total of 44 studies for consideration<sup>6-51</sup>. Three of the 46 selected publications were non-English language and there were four non-English language papers among the 34 publications that were excluded.

Identification and selection of the studies are summarized in Figure 1.

### Study classification

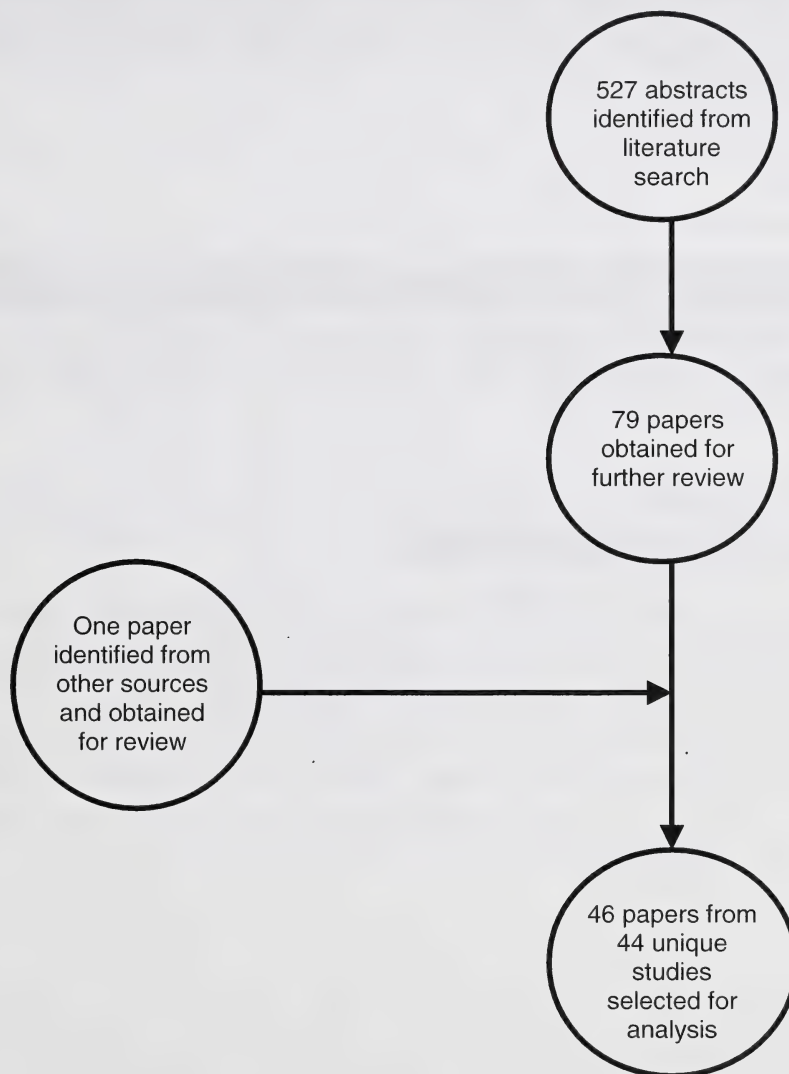
Table 4 shows numbers of studies reviewed by area of application and study design. Further details of each study are given in Appendix B. Thirty five of the studies considered clinical outcomes, and 18 administrative outcomes. Some form of economic analysis was included in 19 of the studies and all but one of these also included clinical and/or administrative details.

**Table 4: Summary of selected studies**

Study design	Type of application			
	Neonatal, pediatric	Adult, hospital and clinic	Emergency care	Home care
Large RCT				3
Small RCT				3
Prospective comparative		2	3	4
Retrospective comparative	5	1	2	2
Case series	11	7		1
<b>Total</b>	16	10	5	13



**Figure 1: Identification and selection of studies**





The settings for the studies and the countries in which they were conducted are shown in Tables 5 and 6.

**Table 5: Settings for telecardiology studies**

Type of setting	Type of application			
	Neonatal, pediatric	Adult, hospital and clinic	Emergency care	Home care
Major hospital and smaller hospital	11	2		
Hospital and outreach clinic or general practice	4	7		
Hospital and home follow up	1	1		12
General practice and home follow up				1
Hospital – consultant			1	
Within hospital			1	
Ambulance - hospital			3	

**Table 6: Origin of studies**

Country	Number of studies
USA	28
UK	4
Italy	3
Greece	2
Greece and Italy	1
Australia	1
Brazil	1
Canada	1
Denmark	1
India	1
Norway	1



## Study quality

Tables 7 to 9 give summary details of the quality scores for the selected studies. Quality scores for individual studies are given in Appendix B.

Table 7 shows the numbers of studies in each application by the performance scores that they were given, out of a maximum of 10. Those in category (i) were of good quality, with adequate and appropriate detail provided for each study. The remainder were of poorer quality. The 21 studies in categories (iii) and (iv) would give some concern as to the validity of their results, as there were some important limitations in all five of the areas of interest given in the Methods section and in most cases relevant information was missing or given in only minimal detail.

**Table 7: Performance scores for selected studies**

Summary performance score		Number of studies			
		Neonatal, pediatric	Adult, hospital and clinic	Emergency care	Home care
(i) (Good)	8.0 – 10.0	2	0	2	6
(ii) (Fair)	6.0 – 7.5	5	4	1	3
(iii) (Fair to Poor)	4.0 – 5.5	3	4	1	3
(iv) (Poor)	≤ 3.5	6	2	1	1

Overall quality scores for the studies are given in Table 8 (the maximum score was 15). Only six studies of home care applications (14 % of the total) achieved the highest score range, corresponding to Category A for reliability. For these, there was confidence that there were adequate descriptions of the studies and that they had been carried out competently. At the other end of the scale, there were 15 studies (34%) in Category D with substantial limitations and of possibly limited validity and 12 (28 %) in Category E that might be regarded as unacceptable for decision makers.



**Table 8: Overall scores and reliability for selected studies**

Overall quality score	Reliability	Implications for decision making	Number of studies			
			Neonatal, pediatric	Adult, hospital and clinic	Emergency care	Home care
11.5 -15	A	High quality; high degree of confidence in study findings	0	0	0	6
9.5 – 11.0	B	Good quality; some uncertainty regarding the study findings	0	0	2	1
7.5 – 9.0	C	Fair quality; some limitations that should be considered in any implementation of study findings	3	2	1	2
5.5 – 7.0	D	Poor to fair quality; substantial limitations in the study, findings should be used cautiously	6	5	1	3
≤ 5.0	E	Poor quality; unacceptable uncertainty for study findings	7	3	1	1

Table 9 shows the mean performance score by type of study design. Studies with stronger designs (RCTs and prospective non-randomized controlled trials) tended to have higher performance scores than retrospective studies or case series, indicating a more rigorous approach to conduct of the investigations and/or more detailed reporting of trial methods and results.

**Table 9: Performance score by type of study design**

Study design	No of studies	Performance score data	
		Mean	Range (SD)
RCTs	6	7.9	5.5 – 9.0 (1.2)
Prospective	9	6.9	4.5 – 9.5 (1.6)
Retrospective	12	4.6	2.5 – 7.5 (1.9)
Case series	17	5.0	1.5 – 8.5 (2.2)





## Quality of economic studies

Of the papers that included cost or other economic information, ten<sup>6,7,8,14,19,22,24,31,42,48</sup> could not be considered as economic studies as they included too few details or did not provide an analysis of the data relating to telecardiology.

Twelve reports included economic studies. One of these utilized cost-effectiveness analysis and all the others used cost analysis. The quality scores for the economic analysis in the reviewed papers varied between 1 and 5 points (Table 10). Only one of the studies that included economic analysis met five or more of the ten criteria for economic analyses given by Drummond et al.<sup>5</sup>. The individual economic quality scores are shown together with the other quality scores in Appendix B.

One good to fair quality economic study was found in home monitoring of heart failure patients and two other studies in that category got low quality scores. Home monitoring, prison care, general practitioner to specialist, and telephone homecare had each one study that got a low score. The scores of neonatal/pediatric care were mainly very low. The average quality rating was 2.69, indicating that the economic studies do not provide enough high quality information for decision making on telecardiology applications.

**Table 10: Classification of quality of economic studies scores**

Score	Number	Quality
10 - 8	0	Good
7 - 5	1	Good to fair
4 - 3	7	Low
2 - 1	4	Very low

## Conclusions reached in studies

General conclusions reached in the reviewed papers are shown in Tables 11 – 14, which also include the quality scores for each study. Further details on the study conclusions are given in Appendix B. The majority of the studies (39 of 44) concluded that telecardiology had advantages over the alternative. However, the quality of 23 of these (59%) was poor or poor to fair.

Impact and quality score details for studies on pediatric applications are shown in Table 11. All but one of the studies were related to teletransmission of echocardiography data. Reported benefits from several studies included savings in time and cost through avoiding unnecessary referrals. Only three of these 15 studies were of fair quality, with the remainder providing weaker evidence. The quality of economic analyses in the six studies where they were included was low or very low.



The other pediatric study, on monitoring of pacemaker performance, was considered to provide weak evidence of benefit.

**Table 11: Impact of pediatric applications**

Indications of telemedicine impact	Performance score (Economic study score)	Study design score	Reliability
<b>Neonatal echocardiography</b>			
Increase in referral rate by pediatricians, educational benefits <sup>6</sup>	4 (Ec = 2)	1	E
Avoidance of unnecessary patient transfer, possible cost advantages <sup>7</sup>	2.5 (Ec = 3)	1	E
Indication of lower costs, decreased time to diagnosis <sup>9</sup>	2.5 (Ec = 1)	1	E
Increased cost compared with courier service, but shorter stay in NICU <sup>10</sup>	6 (Ec = 2)	1	D
No evidence of effect on respiratory therapy <sup>11</sup>	7	1	D
Identified those requiring transfer to hospital. <sup>12</sup>	2.5	0	E
Fewer studies ordered following telecardiology <sup>13</sup>	6.5	0	D
Facilitated early diagnosis, appropriate management, avoided transfers <sup>14</sup>	7	0	D
Telemedicine associated with more tests, higher expenditure <sup>15</sup>	2.5	1	E
Potential to improve patient management and avoid unnecessary transfer <sup>16</sup>	8.5	0	C
Improved patient care, avoided unnecessary transport <sup>17</sup>	5 (Ec = 2)	0	E
Reduction in transfers with cost savings <sup>18</sup>	6.5 (Ec = 1)	1	C
Avoided unnecessary transport <sup>19</sup>	1.5	0	E
Excluded need for further exams, facilitated transfer <sup>20</sup>	8.5	0	C
Excluded need for further exams, facilitated transfer <sup>21</sup>	4.5	0	E
<b>Monitoring of pacemaker performance</b>			
Indication of reliability of monitoring compared to reliance on self-report <sup>8</sup>	3	0	E

[Performance scores and Economic scores have a range of 0 (worst) to 10 (best). Study design scores denote case series (0), retrospective studies (1), prospective studies (2) and RCTs (3 or 5). Reliability values range from E (worst) to A (best).]

Details of studies on applications in adult care are shown in Table 12. Six studies were concerned with support for primary care physicians through transmission of ECG results and feedback from cardiologists. There were benefits through avoidance of unnecessary referrals and identification of patients who required urgent intervention. One study was judged to be of fair quality, with the others having lower reliability.



Two of the other studies indicated benefits from use of telecardiology in a prison service and in support of a cardiac catheterization laboratory. Feasibility was demonstrated but benefits were less clear in studies on use of telemetry outside critical care units and on transmission of nuclear medicine results.

**Table 12: Impact of applications in adult care**

Area of application	Indications of telemedicine impact	Performance score (Economic study score)	Study design score	Reliability
Support for GPs, ECG transmission <sup>22</sup>	Urgent problems identified, managed by cardiologist.	4	0	E
Trans – telephonic ECG monitoring <sup>23</sup>	Avoided unnecessary admissions, gave prompt indication for urgent admission.	5.5	0	D
Support for secondary care, ECG transmission <sup>25</sup>	Identified persons at risk of adverse cardiac events.	2.5	0	E
Support for GPs, ECG transmission <sup>29, 30</sup>	Avoidance of inappropriate referrals to ED and unnecessary investigations, with consequent cost savings.	5 (Ec = 3)	2	D
Support for GPs, ECG transmission <sup>31</sup>	Avoided unnecessary hospitalization, identified undiagnosed cardiac events.	6.5	2	C
ECG transmission, thrombolytic therapy <sup>27</sup>	Identified patients with AMI who were eligible for thrombolysis.	5	0	E
Telemetry for decision making outside critical care units <sup>24</sup>	Value of telemetry may be less than perceived by many physicians.	6.5	0	D
Video link between cardiac catheterisation laboratories <sup>26</sup>	Impact on cases through alteration in technique or in clinical decisions.	6	0	D
Telecardiology in prison setting <sup>28</sup>	Cost benefits arising from increased utilization of the telemedicine service.	7.5 (Ec = 4)	1	C
Transmission of SPECT images from perfusion studies <sup>32</sup>	Alteration in treatment plan for persons with suspected acute coronary symptoms.	2.5	0	E

[Performance scores and Economic scores have a range of 0 (worst) to 10 (best). Study design scores denote case series (0), retrospective studies (1), prospective studies (2) and RCTs (3 or 5). Reliability values range from E (worst) to A (best).]

Table 13 includes information on studies of emergency care applications. Three studies were concerned with transmission of ECG data from ambulance to hospital. All indicated benefits through faster diagnosis and more rapid treatment of patients after





arrival at the hospital. One of these studies was of good quality with the others giving weaker evidence.

A good quality study on use of dobutamine stress echocardiography demonstrated benefits through avoidance of unnecessary hospitalization. A fair quality study indicated benefits from use of a simple fax-based system to provide out of hours support to hospital house officers.

**Table 13: Impact of emergency care applications**

Area of application	Indications of telemedicine impact	Performance score	Study design score	Reliability
Out of hours faxing ECGs to assist management decisions <sup>33</sup>	Avoided unnecessary thrombolysis, other inappropriate treatment	6.5	2	C
Dobutamine stress echo in evaluation of ER chest pain patients <sup>34</sup>	Patients due for admission because of risk factors, chest pain, discharged after normal results.	8.5	2	B
ECG transmission from ambulance to hospital, suspected AMI <sup>35</sup>	Faster ECG diagnosis	3.5	1	E
ECG transmission from ambulance to hospital, suspected AMI <sup>36</sup>	Shorter time to thrombolysis	5.5	1	D
ECG transmission from ambulance to hospital, suspected AMI <sup>37</sup>	Reduced door to diagnosis time and door to needle time	8	2	B

[Performance scores and Economic scores have a range of 0 (worst) to 10 (best). Study design scores denote case series (0), retrospective studies (1), prospective studies (2) and RCTs (3 or 5). Reliability values range from E (worst) to A (best).]

Details of home care application studies are shown in Table 14. The most common application covered was telemonitoring of patients with heart failure. Benefits were demonstrated through reduction in hospital admissions, decreased hospital stay and lower hospital costs, though sustained benefit was not demonstrated in one study. Of the nine studies in this group, four were RCTs of high quality, two were judged to be fair and three were poor to fair. One of the high quality studies also rated as fair to good for its economic analysis.

Two high quality studies showed that home-based rehabilitation was as effective as programs undertaken within institutions. One good quality and one poor quality study indicated useful gains in performance in the monitoring of arrhythmias.



**Table 14: Impact of home care applications**

Area of application	Indications of telemedicine impact	Performance score (Economic study score)	Study design score	Reliability
Telemonitoring of patients with congestive heart failure <sup>41</sup>	Reduction in ER and other admissions	6.5	2	C
Program of education, monitoring and physician notification for patients with heart failure <sup>42</sup>	Hospital admissions and LOS decreased	5.5	1	D
Remote video technology for patients with congestive heart failure and other conditions <sup>43</sup>	Cost savings and improved access to home care support.	9	5	A
Outpatient support for congestive heart failure cases <sup>44</sup>	Small improvement in patient QOL, satisfaction with the program.	6.5	0	D
Electronic home monitoring in chronic heart failure <sup>46</sup>	Reduced ER and hospitalization rates	4.5	2	D
Home telecare, nurse telephone calls for congestive heart failure patients <sup>47, 48</sup>	Readmission charges, ER visits, SS lower in telecare and telephone groups	8.5	3	A
Home telemonitoring of heart failure patients <sup>49</sup>	Video consulting did not show sustained benefit.	5.5	3	C
Telephonic case-management, chronic heart failure patients <sup>50</sup>	Lower hospitalization rate, LOS, costs	8 (Ec = 3)	5	A
Telemanagement for home care, heart failure patients <sup>51</sup>	Fewer readmissions, shorter LOS, lower costs.	8	5	A
Home exercise program using transtelephonic monitoring <sup>38</sup>	NSD in cardiac function between home and hospital groups.	8.5	11.5	A
Home-based, transtelephonically monitored cardiac rehabilitation <sup>45</sup>	Was as effective as on-site rehabilitation.	9.5	2	A
Transtelephonic arrhythmia monitoring <sup>39</sup>	More effective than ambulatory ECG for the detection of arrhythmias.	2.5	1	E
Loop memory recorder in diagnosis of cardiac arrhythmias <sup>40</sup>	Achieved a useful gain in diagnostic yield.	7.5	2	B

[Performance scores and Economic scores have a range of 0 (worst) to 10 (best). Study design scores denote case series (0), retrospective studies (1), prospective studies (2) and RCTs (3 or 5). Reliability values range from E (worst) to A (best).]



## DISCUSSION

This review covers the recent literature on telecardiology to provide an overview of the available evidence supporting its use in major applications. As in previous reviews of telemedicine assessments, we sought studies in which clinical, administrative or economic outcomes were reported<sup>1-3</sup>. Given the limited numbers of controlled telemedicine assessment studies of all types that reported outcomes of this type, we used a broad inclusion criterion for study design that encompassed non-controlled case series with 20 or more subjects. Even with this broader basis for review, only small numbers of telecardiology studies that reported outcomes could be identified.

The areas of benefit identified in the reports and, also, the limited numbers of studies located were consistent with findings from a recent systematic review on the socio-economic impact of telehealth<sup>52</sup>. Most of the studies concluded that telecardiology provided benefits, but such conclusions need to be considered in the context of study quality and reliability. Over half of the small number of studies we identified did no more than establish the feasibility of telecardiology in particular settings. Only nine studies were of high or good quality and quality of all but one of the economic analyses was rated as low or very low. Ten other studies included some economic component but presented too little information to be classified as economic analyses.

The strongest evidence of benefit was provided by the studies on home care applications of telecardiology, particularly on the care of persons with heart failure. A number of the studies in this area could be regarded with high confidence by decision makers. Two of the studies in emergency care were also of high quality and would have provided appropriate guidance.

The majority of the remaining studies, which included most of those on pediatric and adult hospital applications, were of low quality. Twelve of them were judged to have provided findings that were of unacceptable uncertainty for decision makers. Such studies could be regarded as providing no more than preliminary indications of efficacy or other outcomes and would require prompt follow up with more detailed investigations.

Our approach to appraisal of study quality relies on summing values from two scales, one related to study performance and the other to study design. Increasing values in each scale reflect the increasing confidence in the study results and their relevance for decision making. Adding the two types of score recognizes that overall reliability of a study for decision making will depend on both performance and design. The values we selected are based on a judgement regarding relative importance of study attributes. The ratio of one third to two thirds weight for design and performance was taken to reflect the weight that these issues have in determining the usefulness of a telemedicine





study for decision making. This measure of study reliability is based on construct validity and is not an externally validated index.

The quality of economic studies was evaluated on the basis of well – known criteria given in an authoritative text. The overall level of quality for the economic analyses in the studies we considered was low, and did not compare well with that seen in other areas of telemedicine <sup>2,3</sup>.

The appraisal of quality is dependent on the information provided in the reviewed papers. It is possible that some of the studies we considered were of higher quality than indicated, and that local decision makers might have had the benefit of information that was not made generally available through the literature. However, we suspect that in most cases the appraisal of the retrieved papers reasonably reflects the level of confidence that can be placed in the study findings. Also, in most cases, follow-up using studies with stronger methodology may not have been undertaken.

Our review suggests that, as in other areas of telemedicine, formal evidence of benefits from telecardiology remains limited, other than in some specific fields such as home care of patients with heart failure. Decision makers should note the need for follow-up of preliminary studies in order to obtain reliable outcomes data for telecardiology applications.





# **APPENDICES**





## APPENDIX A: LITERATURE SEARCH SUMMARY

Database	Platform	Search Terms
Cochrane Library: Cochrane Collaboration	Licensed Resource: Issue 2, 2003	telemedicine AND cardiology OR heart telecardiology
PubMed: National Library of Medicine: 1966-2003	<a href="http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?holding=icauahslib">http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?holding=icauahslib</a>	<p><b>Search #1</b></p> <p>telemedicine OR tele-medicine OR telecommunication* OR tele-communication* OR telecare OR tele-care OR telehealth OR tele-health OR telenursing OR tele-nursing OR telemanagement OR tele-management OR telecardiology OR tele-cardiology</p> <p>remote consult* OR remote monitor* OR teleconsult* OR tele-consult* OR remote diagnosis OR telediagnosis OR tele- diagnosis</p> <p>cardiology OR cardiol* OR heart OR heart disease* OR electrocardiograph* OR electrocardiography , ambulatory OR chest pain/diagnosis</p> <p><b>1 OR 2 AND 3</b></p> <p><b>Search #2</b></p> <p>telemedicine OR tele-medicine OR telecommunication* OR tele-communication* OR telecare OR tele-care OR telehealth OR tele-health OR telenursing OR tele-nursing OR telemanagement OR tele-management OR telecardiology OR tele-cardiology</p> <p>cardiology OR cardiol* OR heart OR heart disease* OR electrocardiograph* OR electrocardiography , ambulatory OR chest pain/diagnosis</p> <p>cost-benefit analysis OR "cost analysis" OR cost OR "economic outcome"</p> <p><b>1 AND 2 AND 3</b></p>
Science Citation Index	Licensed Resource: Web Interface: 2003 <a href="http://www.library.ualberta.ca/">http://www.library.ualberta.ca/</a>	telecardiology OR telemedicine echocardiography OR cardiology OR heart disease* OR electrocardiogr*



Database	Platform	Search Terms
ECRI's International Health Technology Assessment Database 1990-2003	<a href="http://www.ecri.org/">http://www.ecri.org/</a>	telecardiology telemedicine AND cardiology OR heart diseases
EMBASE: Elsevier	Licensed Resource: OVID Technologies Search Interface Excerpta Medica: 1988 – 2003	<b>Search #1</b> cardiology [SH] OR electrocardiography [SH] OR heart diseases/diagnosis[SH] OR thorax pain/diagnosis [SH] OR heart OR card* “remote consult*” OR “remote monitoring” OR “teleconsult*” telecommunication[SH] OR “telehealth” OR “telecardiology” OR “telecare” OR “telemedicine” OR “telecardiology” <b>1 AND 2 AND 3 OR 4</b> <b>Search #2</b> cardiology [SH] OR electrocardiography [SH] OR heart diseases/diagnosis[SH] OR thorax pain/diagnosis [SH] OR heart OR card* “remote consult*” OR “remote monitoring” OR “teleconsult*” OR telecommunication[SH] OR “telehealth” OR “telecardiology” OR “telecare” OR “telemedicine” OR “telecardiology” cost benefit analysis OR “cost analysis” OR cost OR “economic analysis” <b>1 AND 2 AND 3</b>
CCOHTA	<a href="http://www.ccohta.ca/publications/pubs_e.asp">http://www.ccohta.ca/publications/pubs_e.asp</a>	telecardiology telemedicine AND cardiology
NHS Centre for Reviews and Dissemination CRD Databases: HTA, EED, DARE	<a href="http://nhscrd.york.ac.uk">http://nhscrd.york.ac.uk</a>	telecardiology telemedicine AND cardiology OR heart disease*
CMA Infobase	<a href="http://mdm.ca/cpgsnew/cpgs/index.asp">http://mdm.ca/cpgsnew/cpgs/index.asp</a>	telemedicine AND cardiology
National Guideline Clearinghouse	<a href="http://www.guideline.gov">www.guideline.gov</a>	telemedicine AND cardiology telecardiology remote consultation





Database	Platform	Search Terms
Telemedicine Databases: <ul style="list-style-type: none"> <li>• Meetings</li> <li>• Bibliographic</li> <li>• Programs</li> </ul>	<a href="http://www2.telemedtoday.com/">http://www2.telemedtoday.com/</a>	telecardiology cardiology
World Wide Web Search Engines: <ul style="list-style-type: none"> <li>• Google</li> <li>• AlltheWeb</li> </ul>	<a href="http://www.google.com">www.google.com</a> <a href="http://www.alltheweb.com">www.alltheweb.com</a>	telecardiology remote cardiology remote consult AND cardiology OR" heart disease"

**Notes:**

**Truncation:** The \* symbol is a truncation character that retrieves possible suffix variations of the root word e.g. surg\* retrieves surgery, surgical, surgeon, etc. In databases accessed via the OVID platform the truncation character is \$;

**Limits:** Searches were limited to human; publication dates: **1992-2003**.



## **APPENDIX B: DETAILS OF SELECTED TELECARDIOLOGY STUDIES**

### **Abbreviations**

AMI: Acute myocardial infarction

CCU: Cardiac care unit

ED: Emergency department

€ : Euros

HKD: Hong Kong dollars

HMO: Health maintenance organization

ISDN: Integrated Services Digital Network

Itl: Italian lira

LOS: Length of stay

NICU: Neonatal intensive care unit

NKr: Norwegian crowns

NSD: No significant difference

QOL: Quality of life

RCT: Randomized controlled trial

SPECT: Single – photon emission computerized tomography

SS: Statistically significant

### **Quality scores**

In the following tables, quality scores are given for each study. The numerical values for total quality and performance scores are included together with letters showing the categories from Table 3, which give an indication of the confidence that might be placed in the study results. An economic quality score (maximum 10) is also included for those studies that included economic analysis.



## Pediatric applications

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Rendina et al. 1997 <sup>6</sup> Non-randomized study with retrospective controls.	To assess the effects of neonatal echocardiogram transmission on patient management.	Transmission of neonatal echocardiograms for immediate interpretation and availability of videoconferencing for case consultations. Cost analysis of medical costs.	A telemedicine system between a university hospital and a regional medical centre in North Carolina, USA. 100 echocardiograms from 48 babies were transmitted. Historical data from 38 babies provided the control.	Reasons other than availability of telemedicine might have contributed to a reduction in hospital stay. Projection of savings equated stay in neonatal intensive care unit with total hospital stay.	<b>Total:</b> 5 [D] <b>Performance:</b> 4 [iii] <b>Economic:</b> 2	Hospital stay decreased by an average of six days in the telemedicine group representing an annual saving of \$ 1.3 million. The differences were, however, not significant in this small sample.	Indication of benefit and cost advantage from a preliminary study. Authors noted an increase in referral rate by pediatricians and educational benefits.
Finley et al. 1997 <sup>7</sup> Case-control study and non-controlled, prospective clinical series.	To evaluate the effect of echocardiogram transmission on image quality, diagnostic completeness, diagnosis and patient transfer and to determine the costs associated with the network.	Neonatal echocardiograms and those from older children were transmitted for interpretation by pediatric cardiologists. Transmitted studies were compared with repeat in-person studies in 26 cases.	During two years 135 studies were transmitted from six regional hospitals to a tertiary-care hospital in Halifax, Canada.	Only limited details of interventions following diagnosis. Few details on basis of cost estimates which do not include lost earnings for parents	<b>Total:</b> 3.5 [E] <b>Performance:</b> 2.5 [iv] <b>Economic:</b> 3	A comparison of 26 transmitted studies showed no important discrepancies with repeat, 'in person' studies. Use of telemedicine saved unnecessary patient transfer in 31 cases. Cost details: The cost of the network during the two-year study period was C\$ 90,000. The cost of transportation avoided was C\$100,000-118,000.	Long-term experience indicates the benefits of this approach.



## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Vincent JA, 1997 <sup>8</sup> Case series and cost comparison.	To evaluate diagnostic capabilities and cost – effectiveness of telemonitoring for pacemaker follow up.	Patients with pacemakers supplied with telephone monitors after first post implant visit, use of monitors followed for 3 y. Cost estimates based on charges for services.	Children's hospital, Detroit, USA. 96 patients, age 0.2– 32 y, mean 12.0 y.	Cost estimates consider only charges for the emergency transmissions and not those for the entire program. Cost effectiveness is not established by the data that are provided. No indication of patient numbers associated with the emergency transmissions. Patients included both children and adults, discussion is in terms of a pediatric population. Recommendation to follow pacemaker function every month, rather than two months, does not appear to follow from the data presented.	<b>Total:</b> 3 [E] <b>Performance:</b> 3 [iv]	Of 1,372 monthly transmissions made (40% compliance), 99% showed normal pacemaker function. Asymptomatic pacemaker dysfunction in 15 transmissions, needing remedial action. Of 75 emergency transmissions, 92% failed to show abnormalities, there was dysfunction in 8%. For the 75 emergency transmissions monitoring charges were \$5,250 compared with projected charges of \$19,500 for a clinic visit to evaluate pacemaker function.	Indication of reliability of monitoring as compared to reliance on patient/ parent perceived problems. Overall consequences for a health program not entirely clear.

## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Berdusis K, 1997 <sup>9</sup> Cost comparison, case series, retrospective data.	To compare costs of pediatric telecardiology with those of alternative approaches.	Comparison of costs for diagnostic echocardiography for (a) cardiologist travelling to remote site, (b) sonographer travelling to remote site and (c) telecardiology.	Children's hospital and community hospital, Chicago, USA. 76 echocardiogram transmissions over 2.5 y, neonates suspected of heart disease.	Cost comparisons ignore equipment costs for telecardiology; if these are considered, telecardiology is more costly than option (b) and breakeven would not occur. No consideration of option of transferring patient to major centre. Few details of patients, none of management in this abstract.	<b>Total:</b> 3.5 [E] <b>Performance:</b> 2.5 [iv] <b>Economic:</b> 1	Time to diagnosis quickest using telecardiology (1-2 h compared with 4-15 h). Under assumptions made, cost of providing service to patient was \$205 for telecardiology, \$240 for travelling sonographer and \$866 for travelling cardiologist. Telecardiology under these assumptions would achieve breakeven vs option b within 2.5 y.	Supports use of telecardiology because of lower costs and decreased time to diagnosis.

## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Rendina et al., 1998 <sup>10</sup> Retrospective comparison of pre-telemedicine and telemedicine groups.	To assess whether utilization of telemedicine reduces the intensive care length of stay of low birthweight infants.	Transmission of neonatal echocardiograms for rapid interpretation.	NICU at New Hanover, North Carolina, USA. 48 infants in the telemedicine group and 39 infants in the historical control group.	Relatively small numbers of subjects. Length of stay in the NICU has limitations as an outcome measure. Cost estimates did not include personnel-related items.	<b>Total:</b> 7 [D] <b>Performance:</b> 6 [ii] <b>Economic:</b> 2	A statistically non-significant reduction of 5.4 days in the intensive care length of stay in the telemedicine group. NSD in mortality. Economic analysis: The capital start-up costs and fixed line charges increased the cost per echocardiogram by \$33 compared to the overnight courier service.	Indications of increased cost of telemedicine compared with courier service, but lower stay in the intensive care unit for the telemedicine group (not SS). Likely to influence decisions on continuing future use.
Rendina et al., 1998 <sup>11</sup> Retrospective comparison of pre-telemedicine and telemedicine groups.	To determine whether a more rapid turn-around of echocardiographic interpretations and availability of interactive video reduces morbidity of very low birthweight infants.	Use of a telecardiology system for transmission of echocardiograms for expert interpretation.	21 subjects in the pre-telemedicine group and 28 subjects in the telemedicine group. NICU at Fayetteville, North Carolina, USA.	Small numbers of subjects. The objective was to measure whether there was a reduction in morbidity associated with telemedicine, although some of the discussion refers to resource allocation.	<b>Total:</b> 8 [C] <b>Performance:</b> 7 [ii]	A composite index of respiratory therapy intensity and duration was similar in both groups. The results show little evidence of reduction in respiratory therapy utilization due to telemedicine.	No clear benefits from this approach.



# Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Bensky AS, 1999 <sup>12</sup> Case series	To describe use and benefits of tele-echocardiography for neonatal patients.	Use of a telecardiology system for transmission of echocardiograms for expert interpretation.	Children's hospital linked to general hospital, Winston-Salem, USA 1,318 neonatal echocardiograms transmitted over 3 y.	No more than a brief summary of interventions and management decisions. Little information on patients and their outcomes.	<b>Total:</b> 2.5 [E] <b>Performance:</b> 2.5 [iv]	93% of studies to assess patency of ductus arteriosus in pre-term infants, all managed at remote hospital except for 15 who were transferred for surgery. Of 98 studies to exclude congenital heart disease, 53 were positive; 12 of these patients were transferred for management and the remainder scheduled for outpatient follow – up.	Indication that the telecardiology identified those requiring transfer to a children's hospital and facilitated management of others at a remote hospital, avoiding unnecessary transport.

## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
McConnell et al., 1999 <sup>13</sup> Case series, prospective. Blinded comparison of telemedicine and face to face exams.	Study accuracy, patient satisfaction, cost of pediatric telecardiology.	Exams by two cardiologists blinded to each other's findings; personnel performing additional tests also blinded; outcome measures included frequency of additional tests.	21 children referred to rural pediatric cardiology outreach clinic, North Carolina, USA.	Small sample size. Objectives included study of costs, but these were not given. No data other than a cited cost of echocardiography	<b>Total:</b> 6.5 [D] <b>Performance:</b> 6.5 [ii]	Fewer Echo and ECG studies ordered following telemedicine consultation, but did not reach SS. Telecardiology may lessen need for echo exams, with potential cost savings. There were differences in ability of telemedicine physicians to discern subtle aspects of physical exam.	Preliminary study pointing to possible limits of telecardiology. These need to be considered in context, e.g. incidence of disease in the population.

## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Mulholland HC, 1999 <sup>14</sup> Case series (comparative data for accuracy).	To determine whether use of a telemedicine link for transmitting echocardiographic data could assist in the earlier diagnosis of congenital heart disease.	Diagnosis and management plan agreed between pediatrician at general hospital and cardiologist at children's hospital following transmission of echocardiography scan. Documentation of findings and management decisions.	General hospital and children's hospital, Northern Ireland, UK. 63 pediatric patients, ages 1 to 42 days, between September 1995 and September 1996		<b>Total: 7 [D] Performance: 7 [ii]</b>	Major congenital heart abnormalities diagnosed in 14 patients who were transferred to the children's hospital. 28 patients with more minor congenital conditions were managed at the general hospital with follow up by visiting cardiologist. Transfer was avoided for this group and for 19 patients with no abnormality. Initial diagnosis was accurate in 66% of cases, improved to 91% following transmitted scan and consultation. Indicative costs for the telemedicine system over two years was £6,500 with estimated savings through avoidance of 47 ambulance transfers of £ 14,100.	Telemedicine link facilitated early diagnosis and appropriate management for this patient group and avoided unnecessary transfers. Supports continued use of the system.

## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Scholz & Kienzle, 1999 <sup>15</sup> Case series comparison, physician v cardiologist decision.	Comparison of test ordering patterns from physicians (most by telemedicine) and specialists visiting outreach centers.	Recorded details of echocardiography tests ordered by two groups. Community physicians sent echocardiograms to a hospital laboratory for interpretation. Pediatric cardiologists attending outreach clinics ordered and interpreted echocardiograms.	Pediatric cases referred to community physicians or outreach clinics in Iowa, USA.	Use of the proportion of normal tests for those ordered by physicians and cardiologists tends to weaken the message that many echocardiograms ordered using telemedicine appeared unnecessary. Incomplete data on numbers of cases in groups. Process details mentioned that would influence provision of future services.	<b>Total:</b> 3.5 [E] <b>Performance:</b> 2.5 [iv]	For children < 1 year, much higher proportion (73%) of studies ordered by physicians than by cardiologists (8%). NSD in proportion of normal echos on <1 y children for both groups, SS higher normals in tests ordered by physicians in older children, linked to 12% increase in charges. Conclude that selection of patients influences diagnostic yield of pediatric echo services. Economic analysis: Cost calculations and issues mentioned, no details provided.	Unclear. Telemedicine was associated with more tests and expenditure. Other factors might need consideration.



## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Randolph GR, 1999 <sup>16</sup> Case series.	To review feasibility and effects of telecardiology for management of neonates	Retrospective chart review of neonatal echocardiograms.	General pediatric practice Grand Forks ND and Mayo Clinic, Rochester MN, USA.  133 neonates (161 echocardiograms) with suspected congenital heart disease or cardiac dysfunction.	Authors note absence of controls and of information on possible influence of telecardiology on patient outcomes.	<b>Total:</b> 8.5 [C] <b>Performance:</b> 8.5 [I]	31 of 133 initial exams ordered as emergency exams and 101 obtained urgently. Complete diagnosis in 132 patients.  79 of 133 neonates required a change in management or outpatient follow – up; transfer recommended or avoided in 7, immediate change in local management in 25, non – immediate treatment in 47. No change in management for 54.	Study showed potential to improve patient management and avoid unnecessary transfer. Support for continuation of service

## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Sable C, 1999 17 Case series and cost estimates.	To assess whether real time tele – echocardiography and guidance would improve patient management and provide cost and training benefits.	Prospective collection of data on diagnostic accuracy, patient management and revenue.	Link between two NICUs and a major children's hospital, Louisiana, USA. 48 neonates examined over 7 months (60 telecardiology studies )	Further details would be needed to establish cost – effectiveness.	<b>Total:</b> 5 [E] <b>Performance:</b> 5 [iii] <b>Economic:</b> 2	25 studies led to immediate change in management. Five patients were transferred and transfer was cancelled for a further five following results of the echocardiogram. Mean time from request for telecardiology to completion of study interpretation was $43 \pm 30$ min. Savings from averted transport for 5 cases estimated at \$35,000, telemedicine costs at \$24,310. Charges by the tertiary care centre for echocardiography and inpatient care of transported patients were higher during the telemedicine period than in the previous 7 months.	Telecardiology improved patient care, avoided unnecessary transport; indication that this was an effective service for the population covered.

## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Rendina MC, 2001 <sup>18</sup> Quasi – experimental study, retrospective comparison of neonatal data base records.	To investigate effect of immediate tele-echocardiography on rates of neonatal transfer to academic medical centres.	Comparison of transfers of neonates to academic (major) medical centres 18 months before and 18 months after introduction of telecardiology at one regional NICU. Second regional NICU with on-site cardiology expertise acted as comparison institution.	North Carolina, USA n= 2,142 neonates in two Level 3 NICU units.	Some limitations on patient data, authors note study population data were not risk – adjusted. Authors also note absence of some desirable data that were not recorded or were unreliable. Comparatively brief details of analysis and outcomes. Savings estimate based only on figure given for “typical transfer charges”.	<b>Total:</b> 7.0 [D] <b>Performance:</b> 6.0 [iii] <b>Economic:</b> 1	Introduction of telecardiology was associated with a 58% reduction in neonatal transfers [ $p < 0.001$ , CI 30% - 70%]. There was no such reduction at the comparison NICU. Transport savings through transfers avoided estimated at \$150,000 over 18 months.	Indication that availability of telecardiology was effective in providing specialist pediatric advice.

## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Tsilimigaki A, 2001 <sup>19</sup> Case series.	To develop experience in use of telemedicine for remote diagnosis and management of congenital heart disease.	Recording diagnoses and management approaches for children with suspected congenital heart conditions.	General hospital, Crete and Children's hospital Athens, Greece. 93 children with cardiac abnormalities. Over 18 months, 39 teleconsultations with realtime transmission for 17 patients, prerecorded video images for remainder.	Limited information on patient management. Indicative cost comparison does not include staff or fixed cost components.	<b>Total:</b> 1.5 [E] <b>Performance:</b> 1.5 [iv]	17 children diagnosed with major congenital disease, 72 with less serious abnormalities, 4 normal. n=47 transported to major centre for management, 3 of these as emergency cases in first days of life; n = 44 were managed locally. Authors report estimated variable costs for telemedicine in comparison with much higher costs of transport and accommodation at major centre.	Demonstration that telemedicine was capable of providing diagnostic services for children with congenital heart defects and avoiding unnecessary patient transport.
Milazzo AS, 2002 <sup>20</sup> Case series.	To assess adequacy of a system for initial screening diagnosis and management of infants and children with suspected heart disease.	Retrospective analysis of echo studies and chart data.	University medical centre, Durham, USA, linked to 9 outlying centres. 401 echo studies, included 219 patients $\leq 1$ y and 58 $\leq 1$ mo.	No information on treatment outcomes.	<b>Total:</b> 8.5 [C] <b>Performance:</b> 8.5 [i]	Normal diagnosis in 300 studies excluded need for further evaluation. In 98 studies there was a new diagnosis of structural heart disease and immediate transfer of the patient in five of these.	Support for use of the system for remote management of patients.



## Pediatric applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Sable CA, 2002 <sup>21</sup> Case series.	To evaluate impact of telemedicine on delivery of pediatric cardiac care.	Prospective recording of echo use and quality and patient management.	Tertiary care centre in New Orleans and nurseries in smaller centres, USA. 500 studies on 364 infants over 30 mo.	Comparatively limited details on patients and management outcomes in this extended abstract.	<b>Total:</b> 4.5 [E] <b>Performance:</b> 4.5 [iii]	Time from request for echo to completion of videoconference 28 ± 14 min, compare with 12 ± 16 h for video to be delivered by courier. Telecardiology had immediate impact on patient care in 151 transmissions, including transport to major centre for 19 patients. Follow up recommended in further 131 studies, with no change to initial management. No significant abnormality found in 244 studies. Need for consultation avoided in 194 cases, could be delayed in 26, time savings of 4.2 person hours/ week. Suggested unnecessary transport prevented in 14 cases.	Provided support for routine use of telecardiology, potential to improve patient care and efficiency of services.

### Adult applications: Hospital, clinic – hospital, GP - hospital

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Shanit D, 1996 <sup>22</sup> Case series.	To assess tele-support for routine decision making by GPs.	GPs had telephone access to a cardiologist at a cardiac monitoring centre and were able to transmit ECGs for on line cardiac consultations. Analysis of reasons for consultations and management decisions.	93 GPs in 26 health centres, London, UK, linked to cardiology department at a general hospital; 2,563 consultations over 18 mo.	No information is given on management outcomes. A change in referral pattern is said to have been indicated but supporting data are not given. Notional cost values for several items are insufficient to establish economic impact.	<b>Total:</b> 4 [E] <b>Performance:</b> 4 [iii]	81% of patients could be managed by the GP without need of further referral. In 19 % urgent cardiac problems were identified and immediate hospital admission or early outpatient assessment offered, as appropriate.	Indication that patient evaluation can be facilitated using telecardiology, with likely benefits of more timely management and lower costs.

**Adult applications: Hospital, clinic – hospital, GP – hospital (cont'd)**

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Rissam HS, 1998 <sup>23</sup> Case series.	To assess the role of trans – telephonic electrocardiographic monitoring in evaluation of cardiac symptoms.	Monitoring of call centre activity and influence on patient management.	398 patients registered for telephone monitoring linked to Heart Institute, New Delhi, India.	Limited information on patient population and its selection.	<b>Total:</b> 5.5 [D] <b>Performance:</b> 5.5 [iii]	n = 664 symptomatic calls received, 86% related to cardiac symptoms. 94% of 309 ECGs received within 1h of onset of symptoms. Advice given was reassurance for 61%, change of dose 19%, outpatient review 14.6%, urgent hospitalization 5.4%. Of those hospitalized, 17 discharged after medical treatment within 24h, 4 had IV therapy, 3 DC shocks, 6 PTCA, 4 CABG, 1 RF ablation.	Indication that trans-telephone monitoring avoided unnecessary hospital admissions and gave prompt indication for urgent admission, as appropriate.

## Adult applications: Hospital, clinic – hospital, GP – hospital (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Sivaram CA, 1998 <sup>24</sup> Case series.	To assess the role of telemetry in decision making outside critical care units.	Analysis of telemetry data from patients and associated management decisions. Estimates of cost.	VA Medical Centre and university hospital, Oklahoma City, USA. 60 patients with suspected or confirmed cardiac conditions considered to require monitoring.	Authors note that value of telemetry was assessed by non – treating physician and that the role in decision making could have been underestimated. Also, no comparison with non – monitored patients.	<b>Total: 6.5 [D] Performance: 6.5 [ii]</b>	Over 4 weeks there were 297 telemetry events in 56 of 61 patients. 12 telemetry events (4%) resulted in management changes for 7 patients (medication change following 8 of the 12 events). Cost per event influencing patient management was estimated as \$3,474.	Study suggests that value of telemetry may be less than perceived by many physicians and that there may be over – utilization.
Balestri R, 1999 <sup>25</sup> Non controlled series.	To assess model for provision of care to persons on remote islands.	Clinical and cardiological screening of population with all ECGs being read and reported on at major centres.	Tilos, Greece; Pisa and Milan, Italy. 268 of 280 inhabitants of Tilos.	Only limited details of telecardiology component, patients in this feasibility study. Sonography findings included cases of aneurysm but unclear whether teleconsultation was used.	<b>Total: 2 [E] Performance: 2 [iv]</b>	14 persons were identified who needed further cardiac evaluation.	Successful in identifying persons at risk of adverse cardiac events



## Adult applications: Hospital, clinic – hospital, GP – hospital (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Tobis J, 1999 <sup>26</sup> Case series.	To assess the feasibility and accuracy of video link providing on – line coronary images between two laboratories (only clinical findings considered here).	Recording details of impact of video transmission interaction on patient management.	Cardiac catheterization laboratories, California, USA. 40 patients undergoing coronary artery stenting.		<b>Total:</b> 6 [D] <b>Performance:</b> 6 [ii]	There was a significant impact in 23 of 40 cases (58%) through inputs resulting in alteration in technique or in clinical decisions.	Indication of how the video link could assist clinical decisions during interventional procedures.
Mavrogeni SI, 2000 <sup>27</sup> Case series.	To establish feasibility of thrombolytic therapy in remote island communities.	Recording of telecardiology decisions based on ECG findings and consequences for patient management.	Six Aegean islands linked to cardiac surgery centre in Athens, Greece. Patients with symptoms suggesting critical cardiac conditions. 152 ECGs transmitted.	Limited details regarding patients presenting for examination.	<b>Total:</b> 5 [E] <b>Performance:</b> 5 [iii]	Eight of 10 patients diagnosed with AMI were eligible for thrombolysis, administered by GP under cardiologist instruction. All successful, transported to tertiary hospital 6 -8 h later. n = 36 diagnosed with critical conditions other than AMI and n = 62 as non – emergency cases, scheduled for later evaluation at outpatient clinics.	Study established feasibility, likely input to support for routine service.

Adult applications: Hospital, clinic – hospital, GP – hospital (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
McCue MJ, 2000 <sup>28</sup> Cost study using data on consultations.	To evaluate cost savings from telecardiology in a prison.	Compared numbers and costs of telecardiology sessions with those for in-person cardiology consultations at a major hospital. Administrative and billing data used.	Virginia, USA. Link between prison and university hospital. Inmates of prison; 188 telecardiology consults over a 3 y period.	Authors note that payment data were used, as accounting costs were not available for the prison centre.	<b>Total:</b> 8.5 [C] <b>Performance:</b> 7.5 [ii] <b>Economic:</b> 4	Cost per telecardiology service was \$45 higher than that for a conventional consult in 1996, but became \$15 per visit lower in 1997 and \$46 per consult lower in 1998 as numbers of teleconsultations increased.	Clear indication of cost benefits arising from increased utilization of the telemedicine service.

## Adult applications: Hospital, clinic – hospital, GP – hospital (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Scalvini S, <sup>29</sup> 2001, 2002 <sup>30</sup> Prospective comparison and cost analysis.	To evaluate reduction in referral to ED and accuracy of a telecardiology service for GPs.	Comparison of diagnoses by GPs and cardiologists, and consequences for patient management, with cost analysis. GP diagnosis/management plan recorded prior to obtaining patient history and transmission of ECG for review by a cardiologist.	General practices and hospital cardiology department, Origgio, Italy. n = 891 patients with chest pain examined at 150 general practices (subsequent analysis on 5,073 patients from 200 practices).	As noted by the authors, there was no control group. Comparison was between self-reported GP management intentions and subsequent cardiologist decisions.	<b>Total:</b> 7 [D] <b>Performance:</b> 5 [iii] <b>Economic:</b> 3	GPs would have referred n = 106 (11.9%) to ED and requested further investigations on n = 717 (80.5%). Cardiologist sent n = 56 (6.3%) to ED and requested further investigations on n = 178 (20 %). Estimated reduction in cost was Ilt M22.8 – Ilt M 140.1. (In the subsequent study, further investigation was requested by the cardiologist in 17% and 9% were sent to the ED. 17% of those sent to ED returned home without hospitalization; 7 patients in whom telecardiology failed to detect a problem were subsequently hospitalised).	Studies provide support for usefulness of linking GPs to cardiologists for management of patients presenting with chest pain. Some support for further study and continuation of program.

**Adult applications: Hospital, clinic – hospital, GP – hospital (cont'd)**

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Molinari, G 2002 <sup>31</sup> Prospective comparison of GP and cardiologists' diagnoses and consequences for patient management.	To evaluate the role of telecardiology service for GPs in reducing unnecessary hospitalizations and identifying appropriate admissions.	100 GPs with facilities for trans telephonic ECG linked to telecardiology diagnostic service staffed by cardiologists, 82 made use of the service. GP diagnosis without ECG compared with diagnosis by cardiologist after history and ECG had been transmitted.	General practices and cardiology centre, Genova, Italy. 456 consecutive symptomatic patients enrolled over 1 mo.	Assumption that the GP diagnosis would have led to stated decisions on hospitalization. Subsequent management outcomes not given.	<b>Total:</b> 8.5 [C] <b>Performance:</b> 6.5 [ii]	There was agreement between GP and cardiologist diagnoses in 69% of cases. Telecardiology avoided hospitalization for 84 of 134 patients judged by GPs to have a cardiac event and identified a cardiac event in 56 of 322 patients judged not to be at risk.	Indication that this telecardiology approach is a useful approach in management of patients suspected of having adverse cardiac conditions.



## Adult applications: Hospital, clinic – hospital, GP – hospital (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Tuully P, 2003 32 Case series.	To investigate whether Web – based telenuclear medicine was a practical and useful service.	SPECT images from perfusion studies and provisional indication of findings for patients suspected of acute coronary syndrome sent to hospital from local nuclear medicine facility by secure e-mail. Use of Internet permitted consultation between NIM hospital clinician and cardiologist in Perth.	Nuclear medicine facility 5 km from a regional hospital in Kalgoorlie, both linked to main NM centre in Perth, Australia. n = 42 patients with possible acute coronary syndrome.	Limited details available for this preliminary study.	<b>Total: 2.5 [E] Performance: 2.5 [iv]</b>	There were abnormal perfusion studies in 21 patients, two of whom required urgent intervention. 17 studies were normal and four were equivocal. Alteration in the treatment plan for n = 32, including 4 for whom admission or further investigation were unnecessary. No clinically significant variation in scan findings from Internet – based results and those from formal scan interpretation conducted later in Perth.	Use of the Internet to transmit nuclear medicine data is feasible and could be an efficient way of providing information to referring clinicians. Possible indication for further work/ investigation.

## Emergency care applications

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Srikanthan VS, 1997 <sup>33</sup> Prospective comparison.	To evaluate a system for faxing out of hours ECGs to a consultant as a means of assisting management decisions.	Decisions made by senior house officer compared with those by consultant, following fax of ECG, consequences for patient management considered.	Glasgow, UK 112 patients with chest pain of cardiac origin admitted to CCU.		<b>Total:</b> 8.5 [C] <b>Performance:</b> 6.5 [ii]	Consultant agreed with SHO decisions on thrombolysis in 98 patients (87.5%). 8 patients were saved unnecessary thrombolysis, 4 received treatment they would otherwise not have received and choice of thrombolytic agent was changed for 6 patients.	Indication of usefulness of this approach in providing support for non – specialist hospital staff out of hours.
Trippi et al. 1997 <sup>34</sup> Prospective comparison.	To determine the feasibility of dobutamine stress tele-echocardiography (DSTE) in the evaluation of emergency room chest pain patients and the effect of the technology on hospital admission.	Comparison of hospital admission rates between the study groups.	Indianapolis, USA. 163 emergency room patients with no evidence of myocardial infarction on blood tests or ECG underwent DSTE. In the 3 first phases of the study patients with normal DSTE were admitted to hospital, in the 4 <sup>th</sup> phase of the study they were able to be released.	Outcomes of those who were discharged are not discussed.	<b>Total:</b> 10.5 [B] <b>Performance:</b> 8.5 [i]	72% of those slated for hospital admission because of cardiac risk factors and chest pain suggesting myocardial ischemia were discharged after normal DSTE results.	Useful routine service; study informed decision makers in the hospital.

## Emergency care applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Giovas et al. 1998 <sup>35</sup> Clinical series with a control group the characteristics of which are not reported.	To determine whether ECG transmission from an ambulance is feasible and to assess time savings.	An ambulance was equipped with an ECG recorder connected to a notebook computer and coupled to a cellular telephone for transmission to a hospital-based station.	Athens, Greece ECG recorded in 72 cases en route to hospital. Transmission was successful in 90 % of cases on the first attempt.	The details of the control group are not included. No details of actual management in hospital.	<b>Total:</b> 4.5 [E] <b>Performance:</b> 3.5 [iv]	Paramedics needed 2 min to record the ECG on the move and 34 s to transmit it. The ambulance arrived 15 min. after reception. Pre-hospital ECG diagnosis took place 25 min before in-hospital diagnosis for control group patients.	Strong indication to endorse for routine practice.
Ljosland M, 2000 <sup>36</sup> Prospective series, comparison with retrospective data.	To measure impact of telemedicine on thrombolysis for patients with AMI.	ECGs from patients with suspected AMI transmitted from ambulances to a CCU, those diagnosed with AMI taken directly to CCU for thrombolysis. Recording of time to thrombolysis, comparison with historical data.	Ambulances linked to a CCU, Fredrikstad, Norway. 168 patients with possible AMI.	No indication of patient outcome.	<b>Total:</b> 6.5 [D] <b>Performance:</b> 5.5 [iii]	All 168 ECGs were of good quality, 16 diagnostic of an AMI, confirmed in 15 patients on arrival at the CCU. Thrombolysed at median 15 min (8 – 32) after arrival at hospital. This compared to 40 min (10 – 360) for conventional approach.	Study indicated benefit from pre – admission telecardiology



## Emergency care applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Terkelsen CJ, 2002 <sup>37</sup> Prospective comparison.	To evaluate feasibility and influence of telecardiology for patients with suspected AMI being transported to hospital by ambulance.	Patients being transported in ambulance had ECGs transmitted to university hospital and were interviewed by on-call physician, who then alerted local hospital if there were signs of AMI or malignant arrhythmia. Patients transported to the local hospital in conventional ambulances were the control group.	University hospital and general hospital, Silkeborg, Denmark. Over 1 y, 310 patients transported in telemetry – equipped ambulance, 150 in conventional ambulance and 162 who arrived at hospital without use of ambulances.	Some uncertainties regarding equivalence of control group. Transport time to the hospital was significantly longer for the conventional ambulance subjects. Reason for shorter door to needle time for all AMI patients from telemetry ambulances, whether pre-diagnosed or not, is not discussed.	<b>Total: 10 [B] Performance: 8 [I]</b>	250 of 310 patients in telemetry equipped ambulances subjected to pre-hospital diagnosis, which was technically successful in 214 (86%). Median door to diagnosis time 11 min for pre-diagnosis group compared with 16 min for those not pre-diagnosed and 13.5 min for patients transported by conventional ambulance. For 13 patients who were pre-diagnosed, median door to needle time was 38 min compared to 81 min for n = 14 patients transported by conventional ambulance. Door to needle time was also 38 min for n = 3 patients in telemetry ambulances who were not pre-diagnosed.	Indication that pre-hospital diagnosis is technically feasible. Support for further investigation of this approach.



## Home monitoring/care applications

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Sparks et al. 1993 <sup>38</sup> RCT- allocation of patients to home- or hospital-based exercise program.	To determine the effectiveness of a home exercise program using transtelephonic exercise monitoring.	Prospective, two-group experimental, random assignment. Maximal oxygen consumption, blood pressure, pressure-rate product, and workload as outcome measures.	Urban - centered hospital and surrounding community, USA. Twenty cardiac rehabilitation patients.	Small sample size	<b>Total:</b> 11.5 [A] <b>Performance:</b> 8.5 [i]	Cardiac function improved significantly in both groups. No significant difference between groups before or after training.	Indications that trans-telephonic monitoring was an effective supplement to hospital-based monitoring, though not a replacement.
Wu et al. 1995 <sup>39</sup> Controlled retrospective study.	To evaluate the clinical usefulness of transtelephonic arrhythmia monitoring.	Diagnostic yield of transtelephonic arrhythmia monitoring compared to ambulatory ECG recording.	VA Medical Center, Miami, USA. Ambulatory ECG recording and transtelephonic monitoring in 48 consecutive patients and a comparison group of ambulatory ECGs matched for age, sex and indication.	No details were given on how the costs of services were derived. Estimates of cost-effectiveness and of the optimum time period for monitoring were based on a small number of events.	<b>Total:</b> 3.5 [E] <b>Performance:</b> 2.5 [iv] <b>Economic:</b> 3	Transtelephonic arrhythmia monitoring appeared more effective than ambulatory ECG for the detection of arrhythmias. Limiting transtelephonic monitoring to patients with primarily cardiac symptoms and to a 1-week time period would have optimized cost-effectiveness. Economic analysis: Cost effectiveness analysis. Including medical costs. Sensitivity analysis.	Good indication of the efficacy of trans-telephonic monitoring as compared with ambulatory electrocardiography.

### Home monitoring/care applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Grupi C.J, 1998 <sup>40</sup> Prospective comparison.	To evaluate contribution of loop memory recorder in improving diagnosis of cardiac arrhythmias.	Over 15 days findings from ambulatory monitoring with loop memory ECG and transmission compared with those from previous Holter monitoring. ECG transmission by telephone on onset of symptoms.	Ambulatory Holter monitoring, São Paulo, Brazil. 64 patients with inconclusive Holter monitoring for cardiac arrhythmia symptoms.	Comparison is between 15 day monitoring and 1 day Holter monitoring.	<b>Total: 9.5 [B] Performance: 7.5 [ii]</b>	53 of 62 patients completing the study experienced symptoms, and in 33 cases ECG events were observed. 35.5% diagnoses in patients whose Holter monitoring was inconclusive.	The loop recorder achieved a useful gain in diagnostic yield.
Cordasco ME, 1999 <sup>41</sup> Prospective comparison.	To determine whether application of a telemonitoring system could decrease hospitalization and ER visits in patients with congestive heart failure.	Daily monitoring of weight and symptoms using telemonitoring device. Compared hospitalization with that for other CHF patients and a group awaiting cardiac transplant. Follow up for about 1y.	New York, USA 30 patients with severe CHF. Comparative group 16 with severe CHF and 35 ambulatory patients awaiting transplant.	Comparison group different to intervention group and was not monitored on the same basis. Not all outcome measures were available for the comparison group.	<b>Total: 8.5 [C] Performance: 6.5 [ii]</b>	3% of the monitored group had ER admission compared to 22% of non-monitored patients ( $p < 0.05$ ). 43% of monitored group had at least one hospital admission compared to 71% for non-monitored.	Supports use of telemonitoring for patients with CHF; suggests potential cost savings. Authors note the need for follow up with an RCT.

## Home monitoring/care applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Heidenreich PA, 1999 <sup>42</sup> Prospective series retrospective comparison	To determine if a program of education, monitoring and physician notification reduces hospitalization and LOS for patients with heart failure in a community setting.	Patients identified from claims database. Measured their weight, BP, pulse, phoned in data plus details of any symptoms each day. Vital signs checked by computer algorithm, follow-up by nurse if outside acceptable range. Follow-up for 1 y, some patients continued into second year. Hospitalization and number of claims compared with baseline values and those of controls selected from data base.	California, USA 68 patients with heart failure, monitored. Compared with 86 controls.	Some patients were enrolled using a different selection process. Comparison group selected retrospectively, no details of their characteristics. Resource use reported for only 43 of 68 patients in intervention group. High numbers of false – positive notifications by monitoring system.	<b>Total: 6.5 [D] Performance: 5.5 [iii]</b>	Admissions/y and Hospital days/y decreased from baseline for intervention group and increased for controls. Difference between the groups for hospital days/y in the intervention period was SS (4.8 vs 17, $p = 0.05$ ). In intervention group, 294 physician notifications in 53 patients, change in medication in about 1 in 8 of these. Also 1,764 computer – detected abnormalities where vital sign or symptom data had not been entered accurately by patient. No change in QOL (SF - 36) for intervention group, not data for controls.	Suggests telemonitoring may reduce resource use by CHF patients in a community setting.



## Home monitoring/care applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Johnston & Wheeler, 2000 <sup>43</sup> Large RCT.	Evaluate use and costs of remote video technology in the home health care setting.	Study group randomized to video visits as well as in person and telephone visits. Controls had in person and telephone visits only. Used quality indicators and measured use of services and direct and indirect costs.	Home health department in Sacramento, USA. Newly referred patients with congestive heart failure, chronic obstructive pulmonary disease, stroke, cancer, diabetes, anxiety or need for wound care. 102 randomized to intervention, 110 controls.	Depreciation of the video equipment was not considered for the purpose of the study. There were some differences in the composition of the two groups in terms of primary diagnosis, although comparability of groups was considered by the authors, who found that the difference between SF-12 scores for the intervention and control groups was not significant.	<b>Total:</b> 14 [A] <b>Performance:</b> 9 [I] <b>Economic:</b> 4	There were no differences in the quality indicators for the two groups. Remote technology has the potential to effect cost savings and can improve access to home health care staff. Economic analysis: Average direct cost for the intervention group was \$US1,830 compared to \$1,167 for controls. However, average total mean costs, excluding home health care, were \$1,948 and \$2,674 respectively.	The video approach achieved cost savings and improved access to home care support. The paper indicated that the study was influential for decision makers, leading to adoption of the system.



## Home monitoring/care applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Nanevycz T, 2000 <sup>44</sup> Case series.	Outpatient support for congestive heart failure cases.	Patients completed Minnesota Living with Heart Failure Survey. Follow up at 1 and 6 months. Separate physicians survey.	n=50 enrolled from three types of clinics, California, USA. n=21 (57%) of physicians.	Only small proportion of patients used for weight characteristic analysis, significance of which seems unclear.	<b>Total:</b> 6.5 [D] <b>Performance:</b> 6.5 [iii]	57 alerts made to 27 patients, led to 8 medication changes, 11 clinic visits. At 1 month, overall satisfaction with the program was 84%. Small improvement in QOL survey results (-4.5 points $\pm$ 28.5). At 6 months, n=33 returned survey, 76% would use program on a long term basis. 76% of responding physicians said program met their expectations.	Established feasibility, with limited outcomes information. Some indication of support for feasibility study.

## Home monitoring/care applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Ades PA, 2000 <sup>45</sup> Multicentre controlled trial.	To compare the effectiveness of home-based, transtelephonic cardiac rehabilitation with standard, on-site supervised cardiac rehabilitation.	Transtelephonically monitored rehabilitation program with simultaneous voice and electrocardiographic transmission to centrally located nurse coordinator. Controls participated in on-site exercise program.	5 medical centres in USA. 80 patients in the intervention and 50 in the control group.	Study not randomized (but no significant difference in baseline characteristics between the groups). Relatively small study may not detect possible adverse effects.	<b>Total: 11.5 [A] Performance: 9.5 [j]</b>	Transtelephonically monitored rehabilitation was as effective as on-site rehabilitation.	Transtelephonically monitored home-based rehabilitation is effective but additional data on safety and costs would be useful.
Mehra MR, 2000 <sup>46</sup> Cohort study.	To assess the efficacy of electronic home monitoring (HomMed system) in chronic heart failure.	Hospitalization and emergency attendance rates for patients who used a telehealth system over three months were compared with those for a matched control group.	Three US academic health centres. Fifty three patients with congestive heart failure were compared with 60 controls.	The study period was relatively short. No data for matching of controls.	<b>Total: 6.5 [D] Performance: 4.5 [iii]</b>	The treatment group had a 7% per month hospitalization rate compared with 12% for controls; 13 of 21 hospitalizations for the unmonitored group were preceded by an ED visit, compared with two of 11 for those using telehealth system. Compliance rate of 95% for the treatment group.	Strong indication that it was worth proceeding with further use/ investigation of this approach.

## Home monitoring/care applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Jerant AF, <sup>47</sup> , 2001, 2003 <sup>48</sup> RCT and cost analysis.	To compare in congestive heart failure patients the effectiveness of home telecare, nurse telecare calls, and usual outpatient care.	Video-based telecare group received scheduled home visits, telephone group scheduled phone calls.	University of California, Davis Hospital, CA, USA. 13 patients in home telecare, 12 in telephone care and 12 in usual care groups.	Small number of patients. Reported lack of difference in health status between patients in the different groups does not seem to sit comfortably with the reported differences in readmission charges. As noted by the authors, patient self – care information was obtained by self report.	<b>Total:</b> 11.5 [A] <b>Performance:</b> 8.5 [i] <b>Economic:</b> 5	Mean congestive heart failure –related readmission charges 86% lower in telecare and 84% lower in telephone group, significantly fewer emergency department visits in the intervention groups compared to usual care group. There was NSD between groups for self – care adherence, medications, health status and satisfaction.	Simple post-hospitalization monitoring by telephone provides significant economic savings. Home video – based telecare does not offer incremental benefit.
de Lusignan S, 2001 <sup>49</sup> RCT	To examine the acceptability, effectiveness and reliability of home telemonitoring.	Telemonitored patients measured pulse, BP, weight and had the ability to video consult. Controls received standard general practice treatment.	Patients registered at Woodbridge Hill Surgery, UK. 10 intervention and 10 control patients.	Pilot study. Small number of patients.	<b>Total:</b> 8.5 [C] <b>Performance:</b> 5.5 [iii]	Telemonitoring patients complied better with collecting prescriptions for drugs but there were no significant differences in quality of life and Chronic Heart Failure questionnaire scores between the groups. Video consulting did not show sustained benefit.	Pilot results. Benefits in terms of compliance with medication sustained for at least 1 y but no clear benefits regarding clinical outcomes.



## Home monitoring/care applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Riegel B, 2002 <sup>50</sup> RCT with cost analysis.	To assess the effectiveness of a standardized telephonic case-management intervention in decreasing resource use in chronic heart failure patients.	Patients with heart failure randomized into intervention and usual-care groups. Intervention patients received on average 17 phone calls during the 6-month follow-up. Care for patients in the usual care group not standardized, no formal telephonic case-management.	2 Southern California hospitals, USA. 130 patients in the intervention and 228 in the usual-care group.	Only approximately 30% of patients screened included in the study. Intervention may thus be suitable for a limited number of patients only.	<b>Total:</b> 13.0 [A] <b>Performance:</b> 8.0 [I] <b>Economic:</b> 3	Heart failure hospitalization rate 46-48% lower in the intervention group. Heart failure hospital days, multiple readmissions, and inpatient heart failure costs \$5 lower in the intervention group.	A simple intervention can lead to reduced use of resources and cost savings.



## Home monitoring/care applications (cont'd)

Study, study design	Objectives	Approach	Setting and subjects	Limitations	Quality scores	Results/Conclusion	Implications for decision making
Benatar, D, 2003 <sup>51</sup> RCT, cost estimates.	To compare outcomes for patients with telemanagement for home care and those having home nurse visits.	Patients with heart failure (HF) randomized to telemedicine (home monitoring with nurse supervision) or home visits for 3 mo after discharge. Outcomes included readmission, LOS, anxiety, depression and QOL, hospital charges.	University hospital, Chicago, USA 108 patients with a diagnosis of HF in each arm of the study.	Numbers of patients in the study at 6 and 12 mo is not clear.	<b>Total:</b> 13 [A] <b>Performance:</b> 8 [I] <b>Economic:</b> 3	After 3 mo patients in telemedicine group had fewer readmissions (13 v 24, $p < 0.001$ ), shorter LOS (49.5 v 105.0 d, $p < 0.001$ ) and lower hospitalization charges (\$65,023 vs \$177,365, $p < 0.02$ ). There were similar trends at 6 and 12 mo, though differences between the groups were NSS at 12 mo. There was a trend towards greater improvement in QOL scores for the telemedicine group.	Indication that this telemedicine application was an effective intervention for this patient population.



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